Amendments to the Specification

Please add the following new heading and paragraph before page 1, line 3, "BACKGROUND OF THE INVENTION":

Cross-reference to Related Applications

This application is a continuation of copending, commonly assigned Application No. 09/395,869, filed September 14, 1999, the disclosure of which is incorporated herein by reference.

Please amend the two paragraphs beginning on page 2, line 6 as follows:

As described in copending, commonly assigned U.S. Patent Application No. 09/060,278 (Chiang et al, filed April 14, 1998), now U.S. Patent No. 6,606,023 (issued August 12, 2003), the disclosure of which is incorporated herein by reference, composite devices can be prepared by sorting individual devices and then assembling the sorted devices into composite devices. Such a process can be tedious, as it may require that the resistance of each individual device be read. We have now found, in accordance with the present invention, that it is possible to prepare a multilayer assembly from which individual composite devices can be divided. Such an assembly allows preparation of a large number of composite devices simultaneously. Furthermore, because the process described herein allows the patterning of individual layers of the assembly before or after fabrication into the assembly, a variety of different devices can be prepared from the same starting layers. In addition, the composition of the layers can be easily varied, allowing the simple build-up of devices with combined functionality. Various interconnection schemes between layers can be simply implemented, and devices with multiple external electrical contacts can be made without changing the basic manufacturing process. All of these further add to the broad range of different devices which can be inexpensively mass-produced by the process disclosed herein.

This invention provides methods and processes for which various operative steps can be carried out on an assembly which will yield a plurality of devices when subdivided into composite devices by subdividing along both x- and y-directions (where x and y correspond to directions in the plane of the laminar PTC elements). The ability to prepare devices in this way is a significant improvement over other methods, for example that described in U.S. Application No. 09/060,278 (now U.S. Patent No. 6,606,023), because for this invention, individual devices do not need to be individually assembled, increasing the efficiency and

therefore reducing the cost of the manufacturing process. Finally, the method of combining layers of materials to form composite devices disclosed herein allows an extremely simple yet adaptable method for forming a variety of devices without the necessity of changing the basic manufacturing process.

Please amend the paragraph beginning at page 3, line 20 as follows:

In a second aspect this invention provides a polymeric assembly comprising:

(a) a first laminate comprising a laminar polymer element having at least one conductive surface having a pattern;

(b) a second laminate comprising a laminar polymer element having at least one conductive surface having a pattern, said second laminate being secured to the first laminate in a stack so that the stack has first and second external conductive surfaces; <u>and</u>

(c) a plurality of transverse conductive members which run through the first and second laminates between the first and second external conductive surfaces.

Please amend the paragraph beginning at page 8, line 20 as follows:

The PTC compositions used in the present invention are preferably conductive polymers which comprise a crystalline polymer component and, dispersed in the polymer component, a particulate filler component which comprises a conductive filler, e.g. carbon black or a metal. The filler component may also contain a non-conductive filler, which changes not only the electrical properties of the conductive polymer but also its physical properties. The composition can also contain one or more other components, e.g. an antioxidant, crosslinking agent, coupling agent, flame retardant, or elastomer. The PTC composition preferably has a resistivity at 23°C of less than 50 ohm-cm, particularly less than 10 ohm-cm, especially less than 5 ohm-cm. Suitable conductive polymers for use in this invention are disclosed for example in U.S. Patents Nos. 4,237,441 (van Konynenburg et al), 4,304,987 (van Konynenburg), 4,514,620 (Cheng et al), 4,534,889 (van Konynenburg et al), 4,545,926 (Fouts et al), 4,724,417 (Au et al),.4,774,024 (Deep et al), 4,935,156 (van Konynenburg et al), 5,049,850 (Evans et al), 5,378,407 (Chandler et al), 5,451,919 (Chu et al), 5,582,770 (Chu et al), 5,747,147 (Wartenberg et al), and 5,801,612 (Chandler et al), and U.S. Patent Application No. 09/364,504 (Isozaki et al, filed July 30, 1999)<u>, now U.S. Patent</u>

No. 6,358,438 (issued March 19, 2002). The disclosure of each of these patents and applications is incorporated herein by reference.

Please amend the paragraph beginning at page 9, line 17 as follows:

Assemblies of the invention comprise first and second laminates, and may comprise additional laminates. The first and second laminates each comprise a laminar polymer element having at least one conductive surface, e.g. in the form of a metal foil electrode as described below. In this specification, each laminate is referred to as a layer. The laminar elements of the first and second laminates may comprise PTC compositions which are the same, or the layers may comprise different PTC compositions. For example, PTC compositions of different resistivities may be used, and an interconnection scheme devised so that one layer can act as a heater, and a second layer can act as an overcurrent protection device [device~~-~~]. The layers may also comprise PTC compositions of different switching temperatures (i.e. the temperature at which the device switches from a low resistance to a high resistance state) . For example, such a device may be useful for creating a two-tiered PTC temperature sensor, with one layer being the most sensitive for a lower temperature range, and the second layer being the most sensitive for a higher temperature range. Furthermore, one or more of the laminates may comprise a zero temperature coefficient of resistance (ZTC) composition or a negative temperature coefficient of resistance (NTC) composition.

Please amend the paragraph beginning at page 10, line 13 as follows:

The thicknesses of the laminar elements comprising ~~up~~ the assembly used to prepare a composite device may be different. For example, a very thin laminar element may be used as one layer to provide an extremely low resistance, and a thicker laminar element may be used as a second layer to provide mechanical strength.

Please amend the paragraph beginning on page 10, line 20 as follows:

Particularly useful devices made by the process of the invention comprise at least two metal foil electrodes, with polymer elements sandwiched between them. An especially useful device will comprise a stack comprising *n* polymeric PTC elements, each having two metal foil electrodes, and *(n-1)* adhesive layers sandwiched between the PTC elements in an alternating pattern to form a composite device, with the PTC elements comprising the top and bottom components of the stack. This device will have the electrodes electrically connected such that the PTC elements will be connected in parallel, resulting in a composite device

which has a low resistance at 20°C, generally less than 10 ohms, preferably less than 5 ohms, more preferably less than 1 ohm, particularly less than 0.5 ohm, with yet lower resistance being possible, e.g. less than 0.05 ohm. Particularly suitable foil electrodes are microrough metal foil electrodes, in particular as disclosed in U.S. Patents Nos. 4,689,475 (Matthiesen) and 4,800,253 (Kleiner et al), and in copending, commonly assigned U.S. Application No. 08/816,471 (Chandler et al, filed March 13, 1997), now U.S. Patent No. 6,570,483 (issued May 27, 2003), the disclosure of each of which is incorporated herein by reference. The electrodes can be modified so as to produce desired thermal effects and so as to provide electrical contact points for various interconnection points between the layers of the composite device to give the desired functionality, and to provide electrical contact points for mounting the device onto printed circuit boards, sockets, clips, or other suitable applications. Examples of composite devices which incorporate multiple internal and external contact points are illustrated in Figures 16 to 20, 22, and 23.

Please amend the paragraph beginning on page 11, line 4 as follows:

Similar types of metal foil can be used to form the conductive surfaces of the laminates in the polymeric assembly. Alternatively, the conductive surface may be formed from a conductive ink, a sputtered [sputtered-] or otherwise applied metal layer, a metal mesh, or another suitable layer. Particularly preferred conductive surfaces are those which can be etched, e.g. for patterning, and/or soldered easily. The conductive surface of the laminates has a resistivity at 25°C which is at least 100 times lower than the resistivity at 25°C of the polymer element to which it is attached.

Please amend the paragraph beginning on page 14, line 6 as follows:

A preferred embodiment of a device of the invention comprises an additional (residual) conductive member which is secured to the same face of the PTC element as the second electrode, but is separated therefrom. This residual laminar conductive member which, with the cross conductor or other connector, can be present to provide an electrical path to other electrodes, is formed by removing part of a laminar conductive member, the remainder of the ~~of the~~ laminar conductive member then being an electrode. Residual laminar conductive members may be present on both internal and external faces of the laminar elements. The shape of the residual laminar conductive member, and the shape of the gap between the residual member and an electrode, can be varied to suit the desired characteristics of the device and for ease of manufacture. The residual conductive member is conveniently a small rectangle at one end of a rectangular device, separated from an electrode by a rectangular gap. Alternatively, the residual member can be an island separated from the

electrode by a gap of closed cross-section. Devices can also be designed without a residual laminar conductive member, as shown in Figures 12 and 13.

Please amend the paragraph beginning on page 16, line 18 as follows:

The devices of the invention can be of any appropriate size. However, it is an important advantage for applications to make the devices as small as possible. Preferred devices have a maximum dimension of at most 12 mm, preferably at most 7 mm, and/or a surface area of at most 60 mm^2, preferably at most 40 mm^2, especially at most 30 mm^2, and <u>the surface area</u> ~~it~~ can be much smaller, e.g. at most 15 mm^2.

Please amend the paragraph beginning on page 16, line 26 as follows:

The methods disclosed herein make it possible to prepare devices very economically by carrying out all or most of the process steps on a large stack of laminates, and then dividing the laminate into a plurality of individual composite devices. The division of the stack can be carried out along lines which pass through any, some or all of the conductive surfaces, or through any, some or all of the cross conductors. These lines of division, also called isolation lines or delineation lines, can be of any shape suitable for producing devices of a particular configuration, e.g. straight, curved, or at angles. Similarly "functional" lines, e.g. the gaps between an electrode and a residual member, can also be of any suitable shape. The process steps prior to the division can in general be carried out in any convenient sequence. For example, it is often convenient to pattern the internal conductive surfaces prior to assembling the stack, and to pattern the external conductive surfaces after assembly. However, it is possible to pattern both internal and external conductive surfaces prior to assembly. The patterning of a conductive surface can be the same <u>as</u> or different <u>from</u> ~~as~~ that on other conductive surfaces in the stack, depending on the desired functionality of the final device. For example, Figures 5, 6, 8, 9, 11 and 12 show devices which have internal electrodes which are the mirror images of external electrodes. Figures 10 and 18 to 20 show devices which have internal electrodes which are patterned differently than external electrodes. Often, it is useful to pattern conductive surfaces by removing, e.g. by etching, stamping, or milling, conductive material. Alternatively, the pattern can be produced by an additive process, e.g. screen printing, sputtering, or deposition. For some applications, it is useful to remove strips of conductive material in staggered strips alternately from opposite sides of a laminate layer to balance the physical stresses in the product. The resulting pattern will contain gaps or recesses suitable for separating a second electrode from a residual member in a device, separating one device from another, providing delineation for

subdividing the assembly into individual devices, allowing for orientation of individual laminates or the assembled stack, or providing marking.